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ABSTRACT

Since 1969, Toronto's Metropolitan Separate School Board has been rewarding additional monies to "Special Needs" schools within its jurisdiction in the hope of raising educational opportunity in those schools to a more equitable level. The attempt to arrive at a fair system for determining which schools should receive such assistance led in 1974 to a "special need" scale consisting of five basic measures (including mathematics scores, school size, and the number of students from one-parent homes). Although this scale was used for several years, school-based committee members soon demanded that the unit of measure be changed from the school to the individual students. In 1980, the school mean score previously used for the calculation of special need schools was replaced by an individual mean score based on indexes of social context, school context, and student achievement. Schools selected according to these factors for the "Special Needs List" are subsequently arranged into three categories reflecting greater and lesser degrees of need. To help resolve the perennial problem of special need schools selection, a simulation model is needed that would provide a view of various futures within these schools by integrating a Score Generation Model with a Resources Appropriations Model. (JBM)

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A Simulation Model for the Selection of Special Need Schools

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September, 1982

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Abstract

This paper provides a context for and the conceptual design of a model for the selection of a small set of schools from a school system to which extra resources are applied. The small set of schools are those which, upon a number of dimensions evidence a greater degree of need of extra resources to cope with a variety of problems than do the other schools of the school system. The model is presented in its two subsections. No attempt is made in the paper to provide real data nor the results of calculations since the model has not yet been programmed for a computer and the number of variables is too large to manipulate by hand.

Introduction

Since 1969, the Metropolitan Separate School Board, like many of the borough boards and the Board of Education for the city of Toronto, has been selecting schools from within its particular jurisdiction and designating them as "Special Need" schools.[1] These schools were provided with special assistance in the form of extra budget monies in the expressed hope of providing a more equitable educational opportunity for the students in those schools. It was argued that schools having a high proportion of their population of students coming from homes which were culturally, socially and/or economically disadvantaged would not have the resources (under equal funding for all schools) to provide the support systems and out-of-school experiences which accrue to the non-disadvantaged student and which greatly assist him/her in academic achievement. The consequences of extra funding to the "Special Need" schools (it was argued) would be the provision of learning contexts and situations which would, in time, allay the effects (at least academically) of the disadvantage.

The range of types and degrees of problem(s) cited as indicants of disadvantage and "Special Need" in the schools was great. In some schools one or both parents of some students were either inebriated regularly or

worked at very low paying jobs. The students were either abused physically and/or psychologically or were not fed sufficiently to maintain good health.

Some students experienced continuous family quarrelling and/or were required to do the majority of the work associated with raising their siblings and maintaining the household. Other students were allowed complete freedom of movement without parental expectations or set time limits; this usually resulted in contact with the police. As well as the disadvantage to students resulting from lack of money and the resultant lack of food and amenities such as clothing, newspapers, books and magazines, the lack of expectations and time limits, and the lack of appreciation of schooling, there was and is the cultural disadvantage or deprivation. This cultural deprivation not only included students who were immigrants themselves or were of immigrant parents, but also those students from other parts of Canada that were markedly culturally different from those represented by the school milieu of a large urban city such as Toronto. These students tended not to have the experience-base or the schooling behaviours which allowed an easy meshing with the school curriculum and the expectations of teachers.

These types of disadvantaged students created a problem for the schools. The regular budget, common to all schools, did not allow for the marshalling of resources to cope with these students. It was argued that extra funding would make it possible to provide equal educational opportunity for all students. A similar situation was extant in the U.S.A. and federal funds were marshalled to support a variety of programs for the disadvantaged.

Most boards in Metropolitan Toronto had "inner city" committees which recommended schools for inclusion on the list of "inner city" schools. The objectivity of criteria used for selection was open to question since the major determiner of inclusion during the late sixties and early seventies was the eloquence of the principal in his presentation to the Inner City Committee. The problem with all of these attempts at providing funds for disadvantaged schools (from the population of schools) was in selecting the particular schools to receive funds and to determine on what basis the funds would be distributed.

The MSSB was a pioneer in developing scales based on measures of "need" for selecting "Special Need" schools. Schools were ranked on the basis of a variety of criteria including social, environmental, and school

factors. The data used in developing the scales included school size, achievement scores, number of New Canadians, and population density within the effective attendance area of a school.[2] Other measures such as number of police contacts, family income, dwelling type, and numbers of families receiving family assistance were rejected over the years because the measures were unreliable (between school variation was too high), there were differing policies in reporting incidences in the various boroughs, or the statistic was judged not to be a valid measure of "need".

Orginally, a whole set of measures were decided upon, used and cut-off values established. However, they were all ad hoc measures which were deemed valid and reliable but which had never been sufficiently analysed to determine impact or influence on the overall measure of need. The face validity was accepted on a consensus judgement of importance and upon what effect the measure had on the final list of schools, rank ordered from highest to lowest in terms of "need".

In 1974, a factor analytic study (Feeney, 1975) was completed to determine which of the 15 factors then comprising the "special need" scale were important determiners of need. The results of this study reduced the numbers of

measures to five including 1) Grade 4 Math test score on the Canadian Test of Basic Skills, 2) school size, 3) proportion of New Canadians in the school population, 4) proportion of students in school in Special Education classes and 5) proportion of students in the school from one parent homes. These five factors were the only ones which accounted for significant amounts of variations between schools and were not highly correlated with one another.

For 3 years these factors were used (with varying weights each year) as a means of scaling the schools according to "Special Need". However, in 1979 the scaling broke down in such a way that the aggregate scores no longer ranked schools as in the past, nor according to the best judgement of persons who should be knowledgeable (principals and supervisory officers). Some schools dropped drastically in the ranking, while others rose. An initial analysis pointed to two problems. First, a definite but small consistant change had been taking place in the measures at some schools over the years, especially on mobility and achievement scores; the use of various weighting each year had hidden the effects of these changes. Second, the change

in achievement scores had resulted in a bimodal distribution of achievement scores within the population at some schools, effectively eliminating school achievement scores as a measure of "need" (3)

Since the entire scaling was based upon mean school performance on all measures, there was no way to eliminate the effect of a bimodal distribution upon the final "need" score. There had been a growing demand from school-based committee members that the unit of measure be changed from the school to the individual students. Such a change would not only eliminate the problem of a bimodal distribution of achievement scores in a school, but also would perhaps provide for more soundly based measures of "need". Moreover, if such measures could be established within certain broad categories, it was agreed that the distribution of monies could be better directed to the priority need in a school as pointed-up by the measures, instead of, as had been the case, simply uniformily lowering the pupil teacher ratio according to a rank determined by an aggregate need score. (4)

Let us, for a moment, examine these two approaches to determine the philisophical or logical differences

and come to an understanding of the technical differences in measurement.

The School-Mean Score

In this measurement system a mean score for a school is arrived at through a set of calculations which results in a building score, or the particular measure itself occurs as a building score. The mean score for all the schools (system) is calculated. The school's score on a particular measure is the system mean minus the school measure (mean) over the standard deviation (this makes all the school scores standard scores). The plus or minus score resulting then becomes the school's measured need on that subscale and the sum of all the school's measures becomes its measure of need. The schools can then be ranked according to this measure of need and the top number of schools can be given monies.

The Individual Mean Score

In this measurement system the data used in calculation of need is the individual student score or the deviation of the school from the system mean. Instead of calculating a mean achievement score for a school, the number of students who fall into a particular category is taken and the proportion of these to the

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A Simulation Model for the Selection of Special Need Schools

total of such cases in the system is calculated. This proportion is then developed into a standard score by subtracting it from the system mean and dividing by the standard deviation. In the case of the CTBS score a rather complicated regression analysis is done in order to determine, for those grades who do not take the test the predicated number of students who would score one standard deviation below the system mean for the CTBS.(5) Students scoring one standard deviation below the system mean on the CTBS were considered "at risk" or in "need". The predicted number plus the actual numbers of students "at risk" are then subjected to the calculation above to determine a standard score. This particular change in measurement not only puts the emphasis on individual students, but directly onto the particular numbers of students reflecting need on the particular dimension.

The latter approach was adopted for the 1980 calculations of Special Need Schools. The data gleaned from the Student Data File (SDF) and the student achievement linked to the SDF are shown below in three categories titled (1) Social Demographic Characteristics, (2) School Environment Characteristics and (3) Student Achievement Characteristics.

These headings were throught to be the most appropriate descriptors for the variables which clustered together in the factor analysis (Feeney, 1975). However, in a survey of principals and through a number of working committees of educators, a variety of new measures of need were developed and added to the variables already included under these headings. Face validity was the determiner of a measure's inclusion under one of the above three categories of need. The variables listed below, under each category, indicate the operational definition, type of variable and the major source of the data.

Data in three categories were used: social demographic data, school characteristics data, and achievement score data. The social demographic data were gleamed directly from the Student Data File. It included the following variables described below:

1)	Primary Language spoken in the home	-a dichotomous variable; any language other than English or French.
2)	Family status	-a dichotomous variable; single parent families or both parents in home.
3)	Residency type	-a dichotomous variable; any residence designated by an apartment number.

4) Country of Birth -a dichotomous variable; any non-English speaking country of birth.

5) Admission Source -a dichotomous variable; any transfer from other than an MSSB school.

6) Number of Previous Schools attended -a discrete variable having no upper limit; a tally.

7) Years in Canada -a discrete variable having an upper limit of the age of the child.

The school characteristic data were gathered either directly from the Student Data File or from the Ministry of Education School Report completed each year in September by each school. The variables included are listed and described below:

1) Student Mobility -the sum of admissions + transfers out + graduates + retirements divided by the school enrolment on Sept. 30th; a continuous variable.

2) Staff Mobility -the mean number of staff acquired + number withdrawn divided by the staff compliment on Sept. 30th over a two year period; a continuous variable.

3) Student Variability -the mean number of schools previously attended within the schools population; a continous variable.

4) Class Loadings
-JK-SK : No. of classes with > 24 students;
-Primary : No. of classes with > 27 students;
-Junior : No. of classes with > 32 students;
-Intermed: No. of classes with > 36 students;
all discrete variables.

5) Special Education -full time: % of school's population in full-time Special Education;
-withdrawal: % of school's population in part-time Special Education classes;
both continuous variables

The achievement data were gleaned from the results of the Canadian Test of Basic Skills which is given to every student in Grades 3, 5 and 7. The variable is listed and described below:

1) Students at Risk -the number of actual + predicted students who scored lower than one standard deviation below the mean for the system; a discrete variable

Since only grades 3, 5 and 7 were given the CTBS each year it was not possible to establish directly from the results the total number of students "at risk" in a school. Thus, the demographic characteristics of those students who scored lower than one standard deviation below the system mean were used in a regression analysis to provide regression weights which could be used in conjunction with characteristics of students not taking the test to predict the number who would be "at risk". The actual number of students at risk plus the predicted number of students at risk constituted the mumber of students at risk in a school. The data for each of the scales- the Social Demographic Characteristics Scale, the School Environment Characteristics Scale, and the Student Achievement Characteristics Scale were added together to produce a school's Special Need score.

The three indices derived from the data are described below in terms of their respective composite variables:

A) Social Context Index (SOCI) =
Primary language spoken in the home + Family Status + Residency Type + Country of Birth + Admission Source + Number of Previous Schools + Number of Years in Canada.

B) School Context Index (SCI) = Student Mobility + Staff Mobility + Student Population Variability + Class Loadings + Special Education Compliment.

C) Student Academic Index (SAI) = Actual Number of Students at Risk + Predicted Number of Students at Risk.

Each of the variables were simply aggregated within the particular index and since each was a standard score each constituted 1/nth of the proportion of the particular index of which it was part; the "n" being the number of composite variables making the index. The fact that each variable is added into its index in the form of a standard score is legitimate mathematically. However, there is a very real problem in the degree of influence each index has in the total school score given as "School Need Score".
[SNS = SOCI + SCI + SAI;]

The SOCI includes seven (7) variables, the SCI includes five(5) variables and the SAI includes only one(1) variable. Since the SNS is simply additive of the three indices, the influence of each, epecially under conditions of weighting, varies with the number of variables included in it. Thus, the SOCI accounts for 7/13 of the SNS, the SCI accounts for 5/13 of the SNS and the SAI accounts for only 1/13 of the SNS. This particular problem can be adjusted by the application of weighting factor assigned to each index, but it does not solve the very real problem of establishing a weighted relationship to measure of need.

The Special Needs School List

Once a SNS has been derived for each school, the scores are rank ordered from highest "in need" to lowest. Two variables come into play at this point 1) the total amount of program monies and teaching monies together, and the amount of each separately, and 2) the pupil-teacher ratio at each of 3 levels of highest need.

The Distribution of Monies

Each school which appeared within approximately the top one-third of the "Special Needs List" (SNL) received an allotment of monies to be spent on program (program budget) and/or an amount of money based upon two levels of lowered Pupil-Teacher-Ratio (PTR). The top one-third schools on the SNL were further broken down into 3 groups: 1) those 10-15 schools at the very top of the SNL which would receive both program monies and a lowered PTR to 28:1, 2) a second set of 15-20 schools who ranked next to the top of the SNL which received both program monies and a lowered PTR to 28.5:1 and 3) a third group of 20-25 schools just below the first and second sets of schools on the SNL who received only program monies.

The program monies budget was approx. $100,000.00 which increased yearly at about 5 percent. The budget was distributed, according to enrolment, equally among the three designated levels of need. The lowered PTR for the top 30-40 SNL schools amounted to some 65-70 teachers or about 2 million dollars. The amount of monies were equally divided between Level I (28.0:1 PTR) and Level II (28.5:1 PTR) schools with no set increase in the overall amount of monies from year to year. Instead, the number of teachers generated by the lowered PTR was kept constant and the amount of increase was the result only of increased salaries.

The Problem

Every year the problem arose, after the initial variables were approved, as to whether a change in weighting of one or other of the 3 aggregate scores would change rankings significantly or, if the list of schools was acceptable, what were the ways of distributing the monies differently to achieve differing aims (more schools served, fewer schools served, increased or decreased PTRs, no program monies, using the lowered PTR to generate funds to be used for purposes other than hiring teachers). None of these questions could be answered easily since each was asked about data that were available in unorganized fashions and had to be manipulated by hand through successive approximations to meet mathematically unexplicated goals, (eg. Level I and Level II monies should be approximately equal despite the differences in PTR). The time and effort required to answer these questions was sufficient incentive for this writer to explore the possibility of modelling the distribution of monies to Special Need schools for simulation. A simulation model would allow many of the "what if" questions cited above to be answered easily and directly.

The Simulation Model

The simulation model is presented in two sections: the Score Generation model and the Resources Appropriations model. The two models represent an entire process linked by a set of interfacing decisions. The reasons for their separate presentation are three-fold. First, the models are different in time; chronologically the Score Generations (SG) model must be completed prior to any processing of the Resources Appropriations (RA) model. Second, the processes are different in kind; the SG model represents a quantification of the reality of a single entity along a dimension. The SG model represents values of variables along a dimension of "need" for a school; the RA model takes the set of scores for a school system and apportions the resources available according to a set of decisions about limits or levels of the operating variables. Third, the two models are different in function; the SG model produces a score for a school; the process is reiterated for each school in the system. The RA model takes the output of the SG model, rank orders them by score, and then uses them as input to apportion resources. Separating the presentation of the models provides a clearer picture of the dynamics of the variables involved in each process and highlights the different processes in each.

The Score Generation Model

The model itself is shown in Figure I. It is schematically a very simple model. Each subscale dimension is shown with its constituent variables. Each of the variables has a concomitant level and rate.

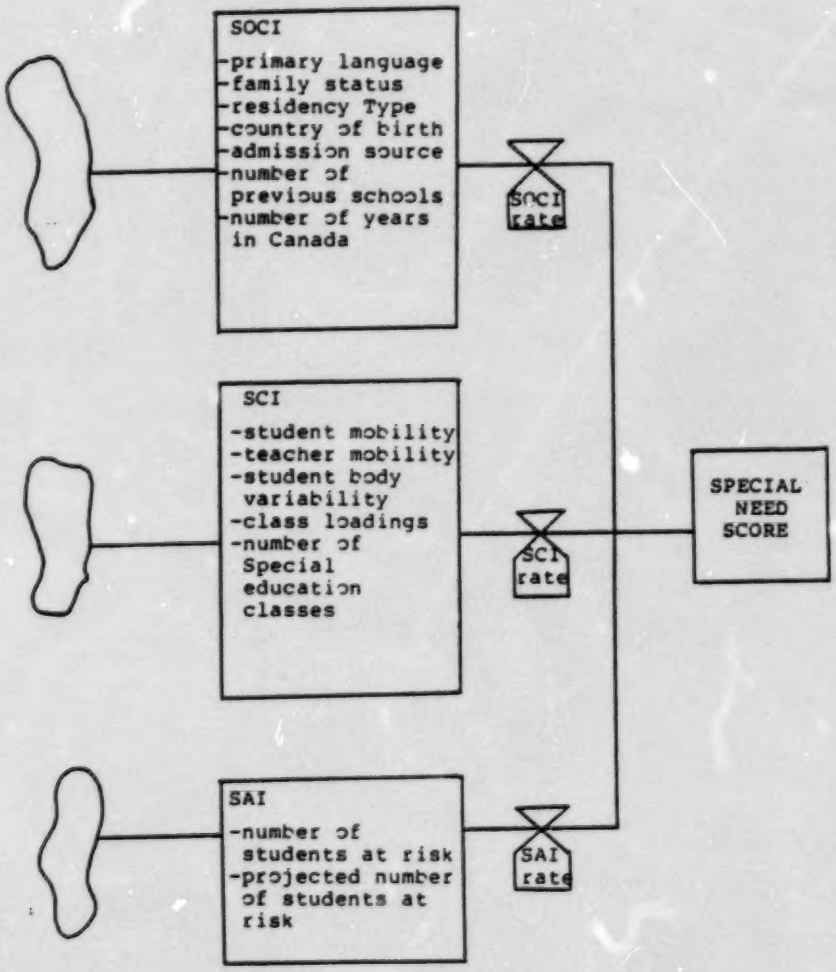

Figure I The Special Needs Score Generation Model

Note: the rates in this model are the weighting factors which might be applied by the committee.

Table I Decision Rates, Factors, and Variables involved in Process of Determining Special Need Rank

DECISION RULES	SCHOOL	School 1	School 2	School 3	School 4	School 5	School 6	School 7
	ENROLMENT							
	VARIABLES IN SOCI							
	WEIGHTING FACTOR SOCI							
	-primary language spoken in home							
	-family status							
	-residency type							
	-country of birth							
	-number of years in Canada							
	-admission source							
	-number of previous schools attended							
	SCORE ON SOCI							
	VARIABLES IN SCI							
	WEIGHTING FACTORS SCI							
	-student mobility							
	-staff mobility							
	-student body variability							
	-class loading							
	-number of special education classes							
	SCORE IN SCI							
	VARIABLES IN SAI							
	WEIGHTING FACTOR SAI							
	-number of Students "at risk"							
	-projected number of students "at risk"							
	SCORE ON SAI							
	SPECIAL NEED SCORE							
	RANK							

Note: Data are not included for reasons outlined in the Text

Table I shows each of the constituent variables and the 2nd column on the extreme left allows a rate to be introduced for the variables. Given successive interactions on the process, one could determine the Special Need Score in a selected future year assuming previous trends (defined by the rate variables) remained constant. In this particular example, the object was not to establish the projected SNS but to simply model the process of the production of a SNS. Thus the rate variables have been set at zero (i.e. the levels of each variable are held constant at the measured value of it).

As pointed out in the general introduction, the SN Score = SOCI + SCI + SAI. Each of the indices could have a weighting applied to it by the SN committee. The application of a weight is shown in the column on the extreme right of Table I and in the model by the rate symbol on each index. Table I does not include data. The reasons for this are two-fold. First, the paper is a model for the simulation of Special Need Schools and not the actual simulation. Second, the application of decision rules, of which these can be many at this stage, change the data (scores) and make it difficult to see the explanatory purpose of the model.

Each of the variables can have applied to it a decision rule. The rate of increase or decrease to a maximum level of any or all variables can be introduced as can an enrolment change over time. The model itself is also open to a specification of the periodicity of the change. For most purposes, and within essential time periods of change for most variables, a year would be considered reasonable. It is important to design the model to operate in an interactive mode over time since variables such as admission source, years in the country, student and staff mobility and number of students at risk

can all vary on a yearly basis. The successive changes can provide results for a variety of "what if" questions and to establish futures under the assumptions of certain trends continuing into the future.

An example of a testing condition would be as follows: The enrolment which has been increasing at all schools at a rate of 5% will slow down and become a negative increase in 5 years. The rate of decrease will be -1% per/year, leveling off when the schools reach 95% of their maximum enrolment. The main reason for this slowing rate of increase and eventtual decrease in enrolment is slowing immigration. As a result the "primary language spoken in the home" and country of birth will decrease, but number of years in the country will increase. If all other variables are held constant, and using measured values for each of the variables the model can be used to generate the Special Needs score for each school. In this particular example the rank ordering would not change because the rates of variables were applied to each school or across the system. If, instead, the trends of previous years for each school were assumed to continue, then the applications of rates and levels would apply differently to each school resulting in quite different ranking. In such cases the model could be used to test its sensitivity to changes in certain variables, either separately or in combination.

The Resources Appropriations Model

In contrast to the Score Generation model, the Resources Appropriations model is a non-linear dynamic model driven primarily not by data or measures from the environment, but by decision rules associated with resources. Figure 2 showns the RA model.

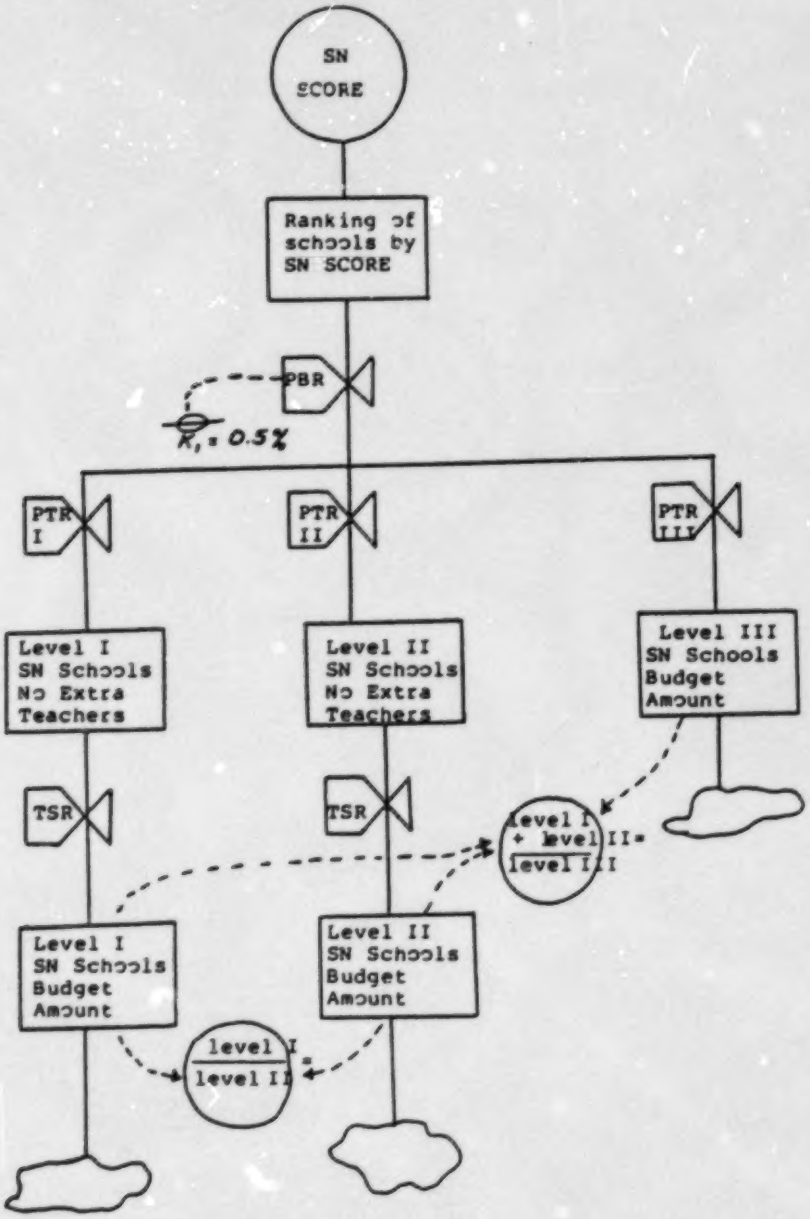
SN SCORE
Ranking of schools by SN SCORE
PBR
K1 = 0.5%
PTR I
PTR II
PTR III
Level I SN Schools No Extra Teachers
Level II SN Schools No Extra Teachers
Level III SN Schools Budget Amount
TSR
TSR
level I + level II = level III
Level I SN Schools Budget Amount
Level II SN Schools Budget Amount
level I = level II

Figure 2 Resources Appropriations Model Showing Rates and Flows (see Text for symbol explorations)

Special Need Scores feed into the RA model from the SG model. The schools are rank ordered according to SN score from highest (most in "need") to lowest (least in "need"). The Program Budget Rate (PBR) is then set, based upon the number of schools selected. The rate is $100,000.00/year with a 5%/year inflation factor allowance. The $100,000.00 is distributed across the schools on the basis of approx. $2.45/pupil. The amount per pupil can vary between years (not counting the 5% inflation factor) because the number of students making up the SN schools can vary slightly.

The distribution of Program Budget Amounts is constrained so that the sum of monies for Levels I and II will equal the monies allotted to Level III. The Pupil Teacher Ratio (PTR) is fixed for Levels I, II and III: for Level I the PTR is 28.0:1, for Level II the PTR is 28.5:1, while for Level III it is 30.0:1. Since the standard PTR is 30.0:1, the Level I and II lowered PTR generate extra teachers or an equivalent amount of money based upon the average Teacher Salary Rate (TSR). The constraint upon these levels is the equivalence between budget amount (number of teachers) for Level I and Level II. These two constraints equal numbers of extra teachers, and one-half the program budget monies for Level II schools result in the provision

of cut-offs between each of the levels. Obviously the cut-offs may not necessarily land between schools. The nearest break between schools satisfying the constraints is selected.

With this model a number of futures can be tested, but the logic of the model does not suggest an iterative approach. The Score Generation model is amenable to iteration with a yearly periodicity; the results of such a process are then fed into this model to determine the set of schools and costs under selected program budget amounts and pupil-teacher ratios. Projected budgets for Special Needs can be determined by varying the amount and application of each rate PBR, PTR and TRSs. As well, different constraints can be applied for equality among levels.

Conclusion

A simulation model has been described for the selection of Special Need Schools. Because of the nature of the variables involved and the nature of the process, it was necessary to separate the model into two parts or sections: a Score Generation model and a Resource Appropriations model. The former proved to be a model amenable to iteration over time while the logic of the latter did not suggest iteration. Examples of rates and levels were provided as were examples of futures or scenarios.

It is the aim of this author to program these submodels and to integrate them so that the model can actually be used to provide a view of various futures within Special Need schools.

Footnotes

1) The Metropolitan Separate School Board (MSSB) has called its selected schools "Special Need" schools and they are designated as such by the Board on the basis of a yearly recommendation from the Special Needs Committee. All other boards in Metropolitan Toronto select "Inner City" schools based on a recommendation of the Metro Inner City Committee. It is interesting to note that the Metro committee was established on a coat-tails (so to speak) of the Toronto Inner City Committee. The name stuck despite its inappropriateness to Etobicoke and North York, for example. Because the MSSB covers all of Metropolitan Toronto, the inappropriateness of the name was immediately apparent and thus the use of the term "Special Need".

2) The MSSB has never designated specific areas or limits within Metropolitan Toronto as attendance areas. Instead, students are allowed to go to whatever school they wish. As a result, attendance areas have always been arrived at empirically and densities calculated on the basis of the effectiveness of the attendance area. The calculation of density has, therefore, never been exactly comparable across schools. However, historically and empirically the use of effective attendance area represents an average lower limit of 99.0% +- .5% of the students residing in an area surrounding the school.

3) Although individual measures of achievement were collected on students in Grade 4 using the Canadian Test of Basic Skills (CTBS), not all students were tested nor were the other measures of "need" based on individual measures. The mean performance score was calculated for a school representing all students who had taken the CTBS. Given that there was a relatively homogeneous or uniformly distributed score on either side of the system mean,.a mean score for the school would fairly represent the population. However a mean score did not really represent "need" in the schools where there would be a normal distribution of scores or a bimodal distribution of CTBS scores. In a normal

distribution of scores, across the range of possible scores the mean would not highlight the 50% of the school which was in "need" (below the mean). The equally numerous high achievement scores would absorb the impact of the "low" scores.

This situation is especially evident in a bimodal distribution of scores where one mean represents high achievers and the other low achievers. The two sets of scores factor out each otner giving a mean which is untruly representative of the population of the school with respect to achievement. In this case "need" is not indicated by school based mean CTBS scores.

4) It should be pointed out that little of this approach to individual-student measurement of need would have been possible without the existence of the M.S.S.B. Student Data File. This particular system constitutes a computerized student personal and school demographic record file. Through this system any student entering the system is given a unique number which remains his/hers forever (70 years). This numbering system allows the tracking of a student throughout his/her school life within the M.S.S.B. and as well is used to pre-code his/her answer sheet for the CTBS. The demographic data such as number of years in country, language spoken in the home, number of siblings, position in family, status of home, etc. could be tied to achievement data or retrieved for use in calculations of "need".

5) The regression analysis used a variety of individual social measures with the achievement scores for those students who took the CTBS. The students who took the test were from Grades 3, 5 and 7 in all schools. The number of students in these grades amounted to about one-third of the population of students in a school and represented a reasonable (non-significant for the two samples) cross-section of students and backgrounds. The derived beta weights were then applied to the remaining population for which there were individual social measures and the predicted number of students "at academic risk" were calculated. The sum of the actual plus predicted number of students "at risk" constituted the total number of students "at academic risk" for the calculation of proportion of such students for any particular school.

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